

Claims

1. A method of forming a foam, the method comprising reacting at least one sulfonyl hydrazide chemical blowing agent with at least one curing agent to form the foam, wherein the curing agent reacts with the blowing agent at a temperature below  
5 an activation temperature of the blowing agent.

2. The method of claim 1 wherein the curing agent comprises a waterborne polyamide or polyamine.

3. The method of claim 2 wherein the curing agent comprises an adduct of a transaminated Mannich base.

10 4. The method of claim 2 wherein the curing agent comprises an emulsion of an epoxy adduct of a polyamine.

5. The method of claim 4 wherein the epoxy adduct comprises an epichlorhydrin adduct.

15 6. The method of claim 4 wherein the curing agent comprises an emulsion of an epoxy adduct of a polyamide-amine.

20 7. The method of claim 2 wherein the curing agent comprises an emulsion of an epoxy adduct, the reaction product of a poly (alkylene oxide) momoamine or diamine and a di or polyepoxide, then reacted with a polyamine or a polyamide, or the reaction product of a poly(alkylene oxide) monoalcohol and a polyepoxide, which is then reacted with a polyamine or a polyamide.

8. The method of any of claims 1-7 wherein reacting the at least one sulfonyl hydrazide chemical blowing agent with the at least one curing agent is carried out in the presence of a binder, the binder forming the foam with the blowing agent and the curing agent.

25 9. The method of claim 8 wherein the binder comprises a resin.

10. The method of claim 9 wherein the resin comprises an epoxy-based resin, the curing agent cross-linking the epoxy-based resin.

11. The method of claim 10 wherein the epoxy-based resin comprises an epoxy-terminated polysulfide.

30 12. The method of claim 8 wherein the binder comprises a latex.

13. The method of any of claims 8-12 wherein the sulfonyl hydrazide blowing agent comprises about .01% to about 15% by weight of the sum of the weights of the blowing agent, the curing agent, and the binder.

- 23 -

14. The method of any of claims 8-13 wherein the curing agent comprises about 30% to about 70.0% by weight of the sum of the weights of the blowing agent, the curing agent, and the binder.

5 15. The method of claim 1 wherein the sulfonyl hydrazide blowing agent comprises about .01% to about 15% of the foam by weight.

16. The method of claim 15 wherein the sulfonyl hydrazide blowing agent comprises about 1% to about 10% of the foam by weight.

17. The method of any of claims 1-16 further comprising introducing at least one fire retardant into the foam.

10 18. The method of claim 17 wherein the fire retardant is selected from the group consisting of phosphates, endothermic fillers, char forming agents, tris(hydroxyethyl)isocyanurates, and polyfunctional alcohols.

19. The method of claim 1 further comprising reacting at least one epoxy-based resin with the curing agent.

15 20. The method of claim 8 wherein the epoxy-based resin is a bisphenol A type epoxy resin.

21. The method of claim 8 wherein the epoxy-based resin is a bisphenol F type epoxy resin.

20 22. The method of any of claims 1-21 wherein the at least one chemical blowing agent is p-toluenesulfonylhydrazide.

23. The method of any of claims 1-21 wherein the at least one chemical blowing agent is p,p'-oxybis(benzenesulfonylhydrazide).

24. The method of any of claims 1-23 further comprising introducing at least one low-density filler into the epoxy-based foam.

25 25. A method of forming an epoxy-based foam, the method comprising reacting a sulfonyl hydrazide with at least one curing agent, and at least one epoxy-based resin at a temperature between about 1°C and about 60°C to form the epoxy-based foam.

30 26. The method of claim 25 wherein the curing agent is a waterborne polyamine or polyamide.

27. The method of claim 26 wherein the curing agent is an emulsion of an adduct of a polyamine.

- 24 -

28. The method of any of claims 25-27 further comprising introducing at least one fire retardant into the epoxy-based foam, wherein the epoxy-based resin is capable of cross-linking with the at least one curing agent.

29. A foam produced by the method of claim 1.

30. The foam of claim 29 wherein the foam comprises an epoxy or modified epoxy resin.

31. The foam of claim 29 or 30 wherein the foam formed in a mold.

32. The foam of claim 29 or 30 wherein the foam is formed by spraying a two-component mixture onto a substrate.

33. A fire resistant foam produced by the method of claim 17.

34. The foam of claim 33 wherein the foam comprises an epoxy or modified epoxy resin.

35. The epoxy-based foam of claim 34 wherein the foam is applied as a protective coating on a substrate.

36. A waterborne foamable resin system comprising a resin, a sulfonyl hydrazide chemical blowing agent, the chemical blowing agent having an activation temperature, and a curing agent, the curing agent comprising an amine or an amide, wherein the curing agent is capable of reacting with the blowing agent at a temperature below the activation temperature of the blowing agent to form a foam.

37. The system of claim 36 wherein the curing agent is capable of cross-linking the resin at room temperature, and the curing agent is capable of reacting with the blowing agent at room temperature.

38. The system of claim 36 or 37 wherein the curing agent comprises an adduct of a polyamine.

39. The system of any of claims 36-38 wherein the resin is an epoxy-based resin.

40. The system of claim 39 wherein the epoxy-based resin is a Bisphenol A type resin or a Bisphenol F type resin.

41. The system of any of claims 36-40 further comprising at least one fire retardant.

42. The system of claim 41 wherein the fire retardant is at least one selected from the group consisting of phosphates, endothermic fillers, char forming agents, tris(hydroxyethyl)isocyanurates, and polyfunctional alcohols.

- 25 -

43. The system of any of claims 36-42 wherein the sulfonyl hydrazide chemical blowing agent comprises about .01% to about 15% of the system by weight.

44. The system claim 43 wherein the sulfonyl hydrazide chemical blowing agent comprises about 1% to about 10% of the system by weight.

45. The system of any of claims 36-44 wherein the resin comprises about 25% to about 70% of the system by weight.

46. The system of any of claims 36-45 the curing agent comprises about 30% to about 70% of the system by weight.

47. A foam produced from the system of any of claims 36-46.

48. The foam of claim 47 having a density of less than  $0.6 \text{ g/cm}^3$ .

49. A foam comprising the reaction product of a sulfonyl hydrazide and a waterborne polyamine or waterborne polyamide.

50. The foam of claim 49 wherein the waterborne polyamide is an emulsion of an adduct of a polyamine.

51. The foam of claim 49 or 50 further comprising at least one low-density filler.

55. A two-part chemical blowing agent comprising a sulfonyl hydrazide and a waterborne emulsion of a polyamine.

56. A method of forming a polymeric foam comprising reacting a sulfonyl hydrazide and a waterborne polyamine or waterborne polyamide at generally ambient temperature and generally ambient pressure.

57. A waterborne curable resin system for producing a fire-resistant cured epoxy-based resin, the system comprising an epoxy-based resin, a curing agent, the curing agent comprising a waterborne emulsion of an adduct of a polyamideamine, the curing agent being capable of curing the resin at room temperature, and at least one fire retardant.

58. The system of claim 57 wherein the fire retardant is selected from the group consisting of phosphates, endothermic fillers, char forming agents, tris(hydroxyethyl)isocyanurates, and polyfunctional alcohols.

59. The system of claim 58 wherein the fire retardant comprises a phosphate.

60. A cured composition of any of claims 57-59.

- 26 -

61. A method of protecting a substrate from fire or other hyperthermal conditions, the method comprising applying the composition of claim 60 to the substrate.

62. A substrate with a coating of the composition of claim 60 applied thereto.

5 63. A low density, epoxy-based intumescent fire resistive coating having a density less than about  $0.7 \text{ g/cm}^3$ .

64. The coating of claim 63 wherein the coating has a density no greater than about  $0.4 \text{ g/cm}^3$ .

10 65. The coating of claim 63 or 64 wherein the coating is formed from a waterborne resin.

66. The coating of any of claims 63-65 wherein the coating includes the reaction product of a sulfonyl hydrazide blowing agent.

67. The coating of any of claims 63-66 wherein the coating includes a char-forming polyol and a gas-forming agent.

15